

Commercial Vehicle Propulsion

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Objective

Develop and validate technology, design tools and methodologies to enable the low cost commercial development and operational use of hydrogen and hydrocarbon fueled liquid engines, low pressure booster engines and hybrid engines.

SCHEDULE

- 1993 - Complete analytical studies
- 1995 - Altitude Ignition and low weight pressurization technology verified
- 1996 - Low cost manufacturing processes demonstrated
- Low cost, low pressure rise turbomachinery demonstrated
- Performance / manufacturing tolerance relationship verified
- Hybrid combustion processes verified
- 1997 - Low cost, reliable O2/H2 and O2/HC systems demonstrated

RESOURCES

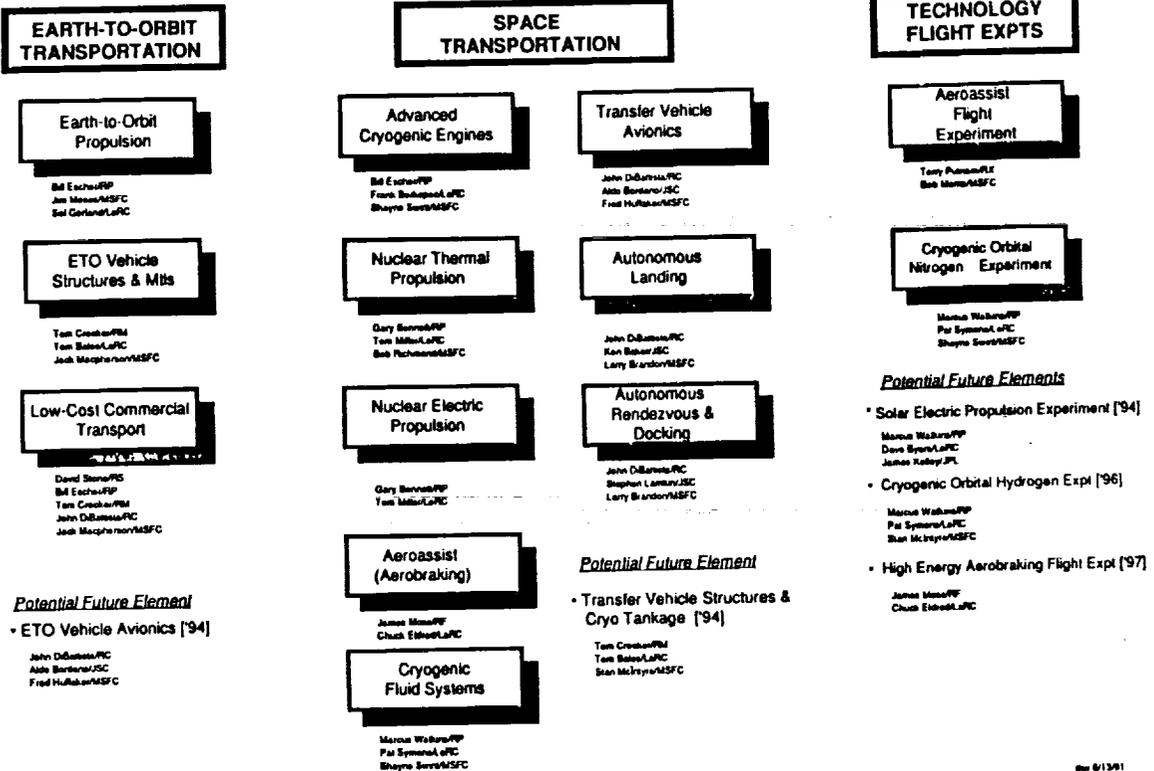
	STRATEGIC	CURRENT	3-X
• 1993	\$ 8M	-0-	2.8M
• 1994	\$10M	-0-	6.6M
• 1995	\$30M	-0-	11.5M
• 1996	\$40M	-0-	16.0M
• 1997	\$30M	-0-	18.6M

PARTICIPANTS

- Marshall Space Flight Center
Lead Center-technology acquisition, component level verification, system level verification
- Lewis Research Center
Participating center-technology acquisition, component level verification

WORK BREAKDOWN STRUCTURE
WITH ELEMENT MANAGERS & LEADS

TRANSPORTATION
TECHNOLOGY PROGRAM



TRANSPORTATION TECHNOLOGY
EARTH-TO-ORBIT TRANSPORTATION

LOW COST COMMERCIAL TRANSPORT

ELEMENT OBJECTIVE: DEVELOP AND VALIDATE TECHNOLOGIES WHICH SHOW PROMISE FOR SIGNIFICANT REDUCTION IN THE COST OF MANUFACTURING, CHECKOUT AND OPERATION OF COMMERCIAL LAUNCH VEHICLES AND UPPER STAGES WHILE PROVIDING IMPROVEMENTS IN SYSTEM RELIABILITY AND AVAILABILITY (REDUCED TURN AROUND TIME)

TWO KEY AREAS OF CONSIDERATION

TECHNOLOGIES NOT BEING PURSUED IN OTHER ELEMENTS OF SPACE TECHNOLOGY PROGRAM

- TAILORED TO A COMMERCIAL NEED
- CURRENTLY BEING EVALUATED UNDER INDUSTRY SPONSORSHIP
- NASA CAPABILITIES/FACILITIES CAN CONTRIBUTE
- MAY PROVIDE ALTERNATE TECHNOLOGY TO MEET NASA NEEDS

APPLICATION (TRANSFER) OF NASA DEVELOPED TECHNOLOGIES TO MEET SPECIFIC COMMERCIAL NEED

- DEFINITION OF INDUSTRY-UNIQUE REQUIREMENTS
- VERIFICATION IN COMMERCIAL SYSTEM ENVIRONMENT (NASA OR INDUSTRY TEST BEDS)
- MAY PROVIDE EARLY VERIFICATION OF TECHNOLOGIES FOR NASA NEEDS

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TRANSPORTATION TECHNOLOGY
EARTH-TO-ORBIT TRANSPORTATION

LOW COST COMMERCIAL TRANSPORT

GROUND RULES:

- INDUSTRY IDENTIFIED INTEREST
- TECHNOLOGY REQUIRES SIGNIFICANT LEVEL OF DEVELOPMENT AND/OR VALIDATION AT OR NEAR FULL SCALE PRIOR TO DEVELOPMENT (NOT FLIGHT HARDWARE DEVELOPMENT ACTIVITY)
- BENEFIT FROM NASA INVOLVEMENT (NOT JUST \$)

IMPLEMENTATION APPROACHES:

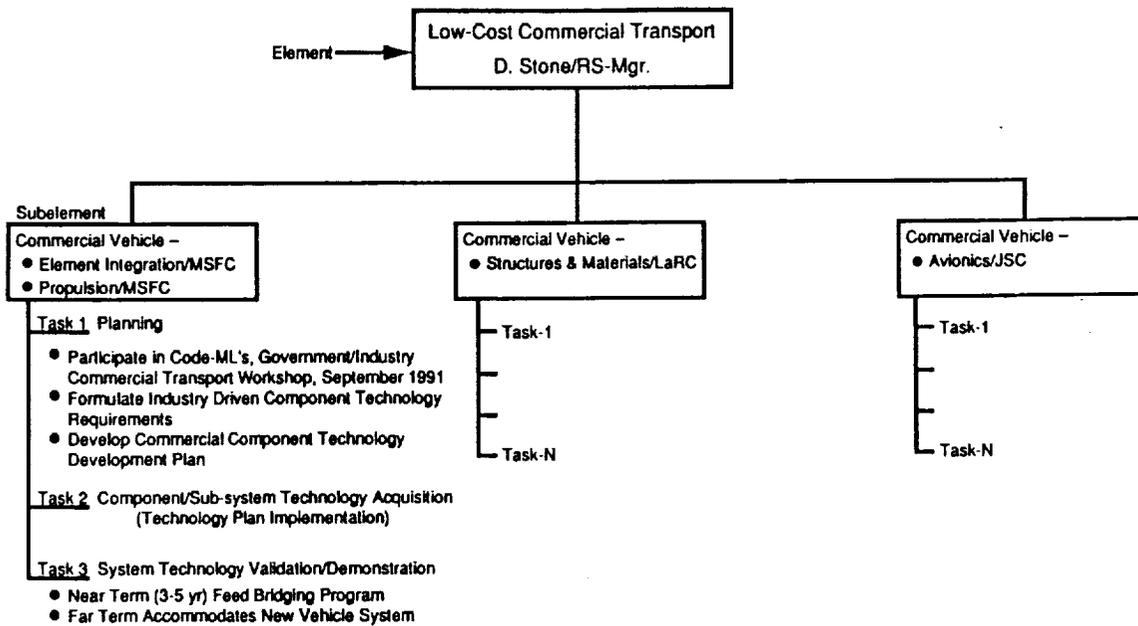
- SPACE ACT AGREEMENT BETWEEN NASA CENTERS AND INDUSTRY (NO NASA FUNDING PROVIDED DIRECTLY TO INDUSTRY)
- JOINTLY PLANNED PROGRAMS UTILIZING NASA FUNDING AND INDUSTRY IR&D (NASA RESEARCH ANNOUNCEMENT TO SOLICIT COMPETITIVE APPROACHES)

CONDUCTS:

- WORKSHOPS WITH INDUSTRY TO DISSEMINATE TECHNICAL DATA EARLY AND MORE EFFICIENTLY

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ELEMENT LEVEL – WORK BREAKDOWN STRUCTURE CODE-RS



LOW-COST COMMERCIAL TRANSPORT TECHNOLOGY APPROACH

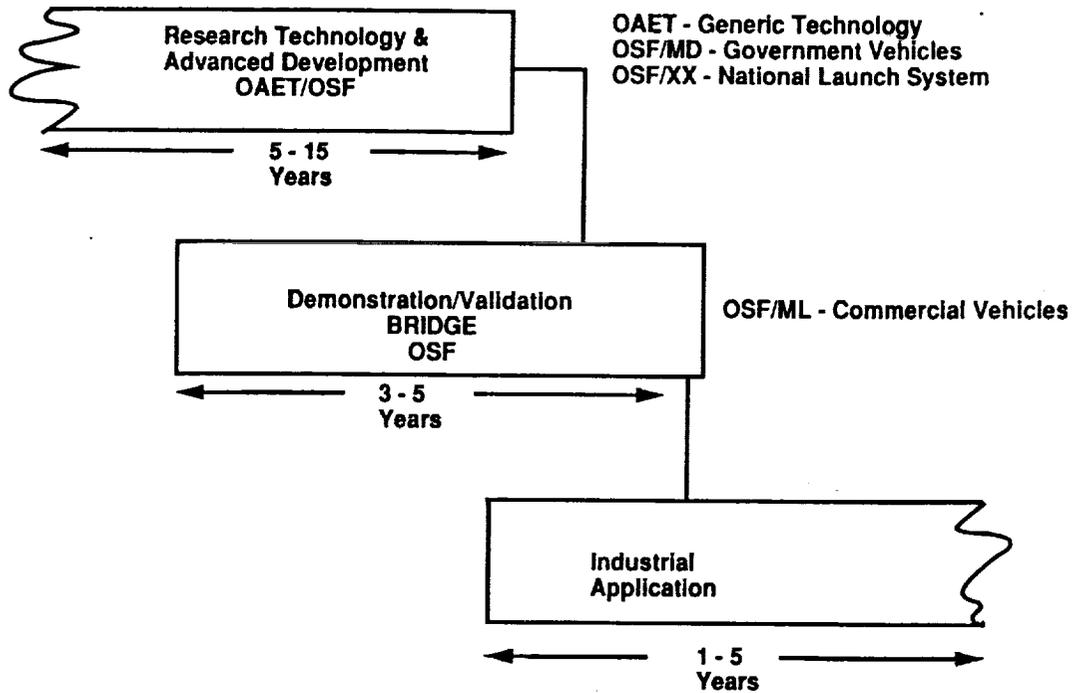
COMSTAC REPORT RECOMMENDATIONS (October, 1990):

- 2/3 of NASA's effort for the next five years should be directed toward the development and infusion of component technology enhancements into the existing fleet of U.S. Commercial ELV's.
- 1/3 of NASA's efforts should go toward a next generation family of launch vehicles that could serve the future U.S. Commercial, Civil and Military needs; (NLS) !

NASA's RESPONSE:

- OSF / Code-ML, proposes a 3-to-5yr, technology demonstration / validation - "Bridging" program to meet the near-term ELV enhancement objectives.
- OAET / Code-RS, will support the Code-ML Bridging Program by providing:
 - Transfer of existing (on-the-shelf) matured technologies to the private sector.
 - Accelerate relevant, on-going technology developments to comply with commercial schedule requirements.
 - Initiate new starts where required to meet the commercial needs.
- OAET / Code-RS, will work with industry to plan and implement a comprehensive systems technology program to enable development of the "next generation" low-cost, commercial ELV's.

EVOLUTION OF SPACE TRANSPORTATION TECHNOLOGY



"COMMERCIAL VEHICLE PROPULSION SYSTEM NEEDS"

Desired Enabling Capabilities	Technology Requirements
<ul style="list-style-type: none"> • Low-Cost O₂/H₂ Liquid Booster Engine System • Evolved Improvements in Existing Hydrocarbon Engine Systems (ATLAS, DELTA) • Family of Mid-Sized O₂/H₂ Upper Stage Engines (35 to 200 K-Lb. Thrust Class) • Low-Cost, Low-Pressure Pump Fed Liquid Rocket Boosters <ul style="list-style-type: none"> - O₂/HC - O₂/H₂ • Hybrid Boosters and/or Upper Stage Propulsion Systems 	<ul style="list-style-type: none"> • NLS /STME To Provide • Implement existing advancements in materials, mfg.- processes, and mechanical elements to affect modernization of turbomachinery, combustion devices, valves, etc. • Advanced Expander Cycle Engine Technology Issues: <ul style="list-style-type: none"> - Improved heat transfer methods - Vacuum Start Techniques - Automated Engine System Checkout Processes • Code-RP / LeRC-MSFC Advanced Cryogenic Engine • Code-RP / MSFC Component Technology Program <ul style="list-style-type: none"> - Ablative Thrust Chamber and Nozzles - Simple Low-Cost Injectors - Low Pressure Rise Industrial Grade Pumps - Low-Cost Lightweight Tank Pressurization Systems • Hybrid Propulsion Technology Issues: <ul style="list-style-type: none"> - Ignition System Optimization - Ballistic Assessment; Combustion Process Analyses Performance Prediction, Fuel Formulation, Flow Analy. - Fuel Grain Design; Strength, Support, Producibility - Propellant Tailoring, Oxidizer Injection optimization - Insulation Characterization, Case & Nozzle - High regression rate fuel chemistry

FOCUSED TECHNOLOGY

LOW-COST COMMERCIAL TRANSPORT / PROPULSION TECHNOLOGIES

SUMMARY

- **Impact:**
 - Through the transfer of existing technological advancements in materials, manufacturing processes, and mechanical elements the existing cadre of O2/HC engines may be enhanced to provide improved reliability with reductions in manufacturing and operations cost.
 - Technologies that will enable the family of O2/H2 expander cycle engines will provide efficient, low-cost, reliable, robust, competitive upper stage propulsion to minimize the dollar/lb. cost to orbit.
 - Low pressure liquid booster engines (O2/HC & O2/H2) and hybrid engines will provide options and new capabilities to commercial ELV's that will reduce operations cost and improve safety and reliability while mitigating environmental effects.

- **User Coordination:**
 - Top level commercial needs are reasonably well understood
 - Detail technology requirements, priority, schedule, and level of maturity required, are TBD
 - Implementation strategy with other Codes is TBD
 - Coordination between NASA, USAF, DOT, and the Commercial Industry is required

- **Overall Technical and Programmatic Status:**
 - Code-ML's Bridging program has merit and momentum
 - Code-RS/RP will participate in the September 1991 Bridging program workshop to drive out technology requirements both near term and long range.

- **Major Technical / Programmatic Issues:**
 - Absence of firm technical requirements (workshop will rectify)
 - The synergy between propulsion technology elements within related ongoing programs (ETO & NLS/ADP) need to be defined in the context of the commercial requirements
 - Lack of inter- and intra-agency strategy and plan
 - There is a need to establish the scope and bounds of the Code-R participation

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